

Effect of Fluorine on Near-Liquidus Phase Equilibria of Basalts

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Volatile species' such as H₂O, CO₂, F, and Cl have significant impact in generation and differentiation of basaltic melts. Thus far experimental work has primarily focused on the effect of water and carbon dioxide on basalt crystallization, liquid-line of descent, and mantle melting [e.g., 1, 2] and the effects of halogens have received far less attention [3-4]. However, melts in the planetary interiors can have non-negligible chlorine and fluorine concentrations. Here, we explore the effects of fluorine on near-liquidus phase equilibria of basalt.

We have conducted nominally anhydrous piston cylinder experiments using graphite capsules at 0.6 - 1.5 GPa on an Fe-rich model basalt composition. 1.75 wt% fluorine was added to the starting mix in the form of AgF₂. Fluorine in the experimental glass was measured by SIMS and major elements of glass and minerals were analyzed by EPMA. Nominally volatile free experiments yield a liquidus temperature from 1330°C at 0.8GPa to 1400 at 1.6GPa and an olivine(Fe₇₂)-pyroxene(En₆₈)-liquid multiple saturation point at 1.25 GPa and 1375°C. The F-bearing experiments yield a liquiudus temperature from 1260°C at 0.6GPa to 1305 at 1.5GPa and an ol(Fe₆₆)-pyx(En₆₄)-MSP at 1 GPa and 1260°C. This shows that F depresses the basalt liquidus, extends the pyroxene stability field to lower pressure, and forces the liquidus phases to be more Fe-rich. $Kd_{\text{mineral-melt}}^{\text{Fe-Mg}}$ calculated for both pyroxenes and olivines show an increase with increasing F content of the melt. Therefore, we infer that F complexes with Mg in the melt and thus increases the melt's silica activity, depressing the liquidus and changing the composition of the crystallizing minerals.

Our study demonstrates that on a weight percent basis, the effect of fluorine is similar to the effect of H₂O [1] and Cl [3] on freezing point depression of basalts. But on an atomic fraction basis, the effect of F on liquidus depression of basalts is xxxx compared to the effect of H. Future studies on kimberlitic and subduction zone magmas, which could have significant amount of fluorine, will need to consider the combined effects of F, Cl, and H on their stability and chemical evolution.

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